https://ntrs.nasa.gov/search.jsp?R=20190001366 2019-08-30T11:00:12+00:00Z

Increment 39/40 ISS Science Symposium
FRUIT FLY LAB

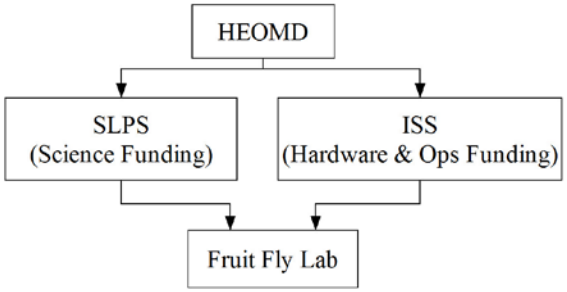
Sharmila Bhattacharya, PhD
NASA Ames Research Center
Date: 11/19/2013

Fruit Fly Lab Overview

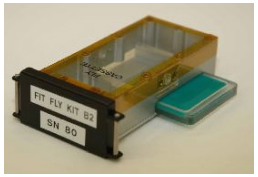
Description and Objectives:

- **Relevance to NASA's space biology program**: Drosophila melanogaster can be used to address Decadal Survey Areas: AH14, AH16, CC2, CC8, CC10

- **Description**: To support multi-generational experiments with Drosophila melanogaster (fruit flies) at various gravity levels (0 to 2 g). The aim is also to include a video monitoring system to measure health and behavior in space.



Drosophila hardware for FFL-01



Drosophila melanogaster (fruit fly)

Approach:

A small diameter centrifuge onboard ISS will provide the capability to study the flies in partial-g and 1-g. The NanoRacks BioRack Centrifuge and µg-Rack will accommodate FIT fly cassettes inside a Type-1 container. It does not currently have video imaging, which is an important requirement, and does not provide full environmental control. A prototype video camera system is currently being worked for the fruit fly laboratory hardware.

Justification:

- Value to Agency (Space Benefit)
  This system enables studies of genetic and molecular biological responses to micro- and fractional-gravity and effects on reproduction in a complex organism that has been extensively used in labs around the world for such studies. This is a capability that is lacking, but desired, by all of the international partners for on-orbit space biology research.

- Value to Public (Earth Benefit)
  Microgravity exposure has unmasked genetic mechanisms in simpler organisms, and needs to be studied in more complex organisms. Strong potential for education outreach paired with science research goals.

Payload Objectives for FFL-01

- **Aim**: Replicate and extend scientific return from FIT experiment, STS 121, 2006 (PI for FIT mission: Dr. Sharmila Bhattacharya, NASA ARC) and validate future Drosophila spaceflight hardware capabilities.

- **Hypothesis**: Space flight will affect host physiological and immune function and alter the dynamics of host-pathogen interactions

- **Science Approach:**

[Note: post flight processing challenging due to delayed sample return (2-5 days post landing)]

  - Effect of in-flight challenge of flies with microbe
  - Imaging of insects during flight - viability, behavior, development
  - Frozen samples for molecular analyses such as protein expression and activity
  - Dissection of and examination of insects post-flight

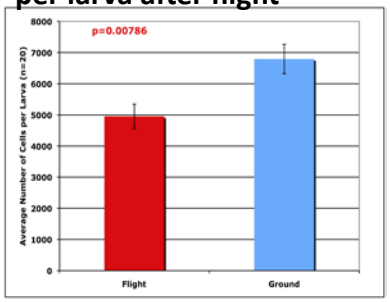
- Immunological, developmental, and molecular changes and lethality assessment following bacterial infection in-flight

Previous space flight data with Drosophila melanogaster:

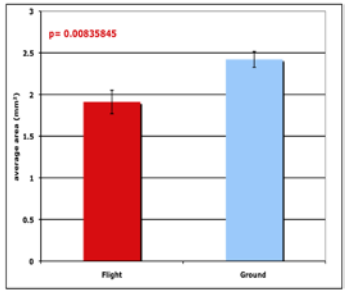
DROSOPHILA SHOW IMMUNE CHANGES AFTER SPACE FLIGHT on STS 121

Published from Bhattacharya laboratory in PLoS ONE 6(1): e15361. 2011. doi:10.1371/journal.pone.*0015361*

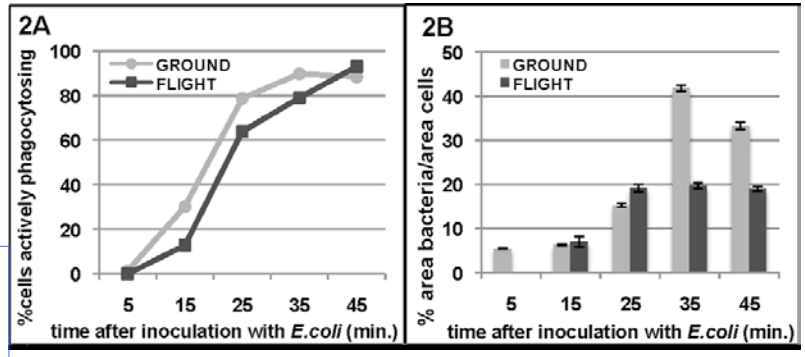
Reduction in the number of plasmatocytes (blood cells) per larva after flight



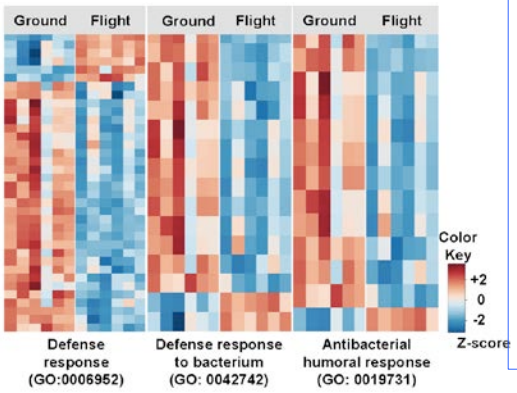
Reduction in the average size of each larva after flight



Reduced phagocytosis efficiency of plasmatocytes in larvae



Whole genome microarray analyses shows reduced expression of genes involved in
- humoral innate immunity
- blood cell maturation
- phagocytosis functions etc.



Why flies?

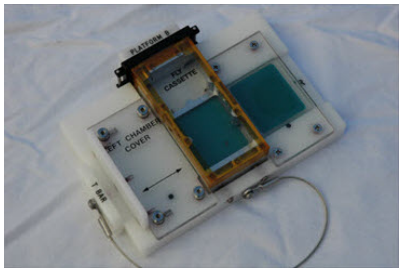
- *High "n" number*
- *Genetically identical animals*
- *Low resource requirements*
- *Short life cycle - multiple generations*
- *Measure response of a whole multicellular animal*
- *Homologous systems e.g. conservation with mammals*
- *Flies used as a model for infection with human pathogens*

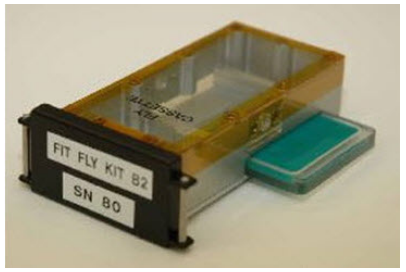
➢Flies mirror many of the innate immune changes observed in humans post-flight, and serves as a useful and simple model for understanding the underlying molecular mechanisms of space flight related effects on host innate immunity

Hardware for Fruit Fly Lab with High Flight Heritage

Existing Hardware Designs

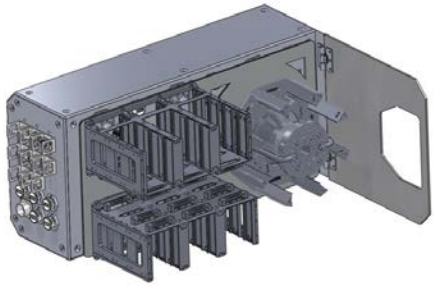
- Fly Cassette
- Change-Out Platform
- Food Tray
- Type 1 Container interface

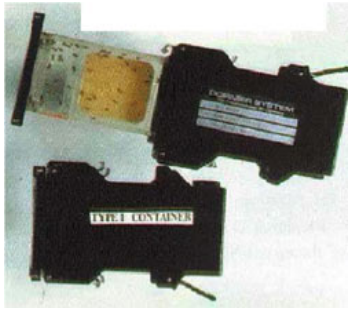




Existing On-Orbit Facilities

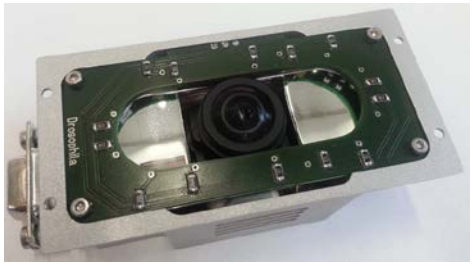
- NanoRack Centrifuge
- Type 1 Container





New Observation System

- Video Capture
- Circadian Lighting



Why do we need such a habitat on the ISS?

Life and Physical Sciences Decadal Survey 2011 - National Research Council

Recommendation stated on Page 150 as follows:

"Invertebrates
The fruit fly (Drosophila melanogaster) and nematode (Caenorhabditis elegans) are highly organized, multicellular organisms well suited to elucidating certain **molecular, genetic, cellular, and physiological responses** to the space environment within and across **multiple generations**. Most importantly for **mutational analyses**, these and other invertebrates are excellent models for studies of **DNA damage/repair and programmed cell death (apoptosis)** and for identifying additive influences of the space environment, particularly **microgravity and space radiation** (important for enabling space habitation rather than fundamental biology). Invertebrates have short life cycles, producing hundreds of offspring within weeks, thereby contributing to the branch of **developmental biology concerned with evolution and development**—in this case, the adaptive effects of multigenerational exposure to microgravity. **Such adaptations could be enhanced using flies with or without gravity sensation**. **Comparative gene microarray analyses of spaceflight-exposed flies** and nematodes can be used to identify gravity-induced changes in expression of orthologous genes."

OF INTEREST TO THE LARGER COMMUNITY

- **5 Recent news paper articles on fruit flies from Jan to Nov of 2013**

  - 1) Featured in **Palo Alto Daily News** on April 7th, 2013 to discuss fly research in space at career day http://www.mercurynews.com/peninsula/ci_23120153/not-your-average-career-day-palo-alto-school
  - 2) Featured in **Orlando Medical News paper** regarding fruit fly work, March 6, 2013 http://orlandomedicalnews.com/a-new-orbit-cms-1586
  - 3) Published as front page article on Jan7th, 2013 in **San Francisco Chronicle** regarding winning Space Florida competition to fly an experiment on SpaceX Mission on cardiovascular function in space using the fruit fly model. http://www.sfgate.com/science/article/Studying-space-travel-with-fruit-flies-4171653.php
  - 4) Featured in **Stanford University Newspaper** regarding Heart Flies project, Jan 28, 2013
  - http://med.stanford.edu/ism/2013/january/fruit-flies-0128.html
  - 5) Interviewed by **Christian Science Monitor** on 11/18/2013 for an article on Fruit Fly Lab on ISS

- **NASA Space Biology has selected a Drosophila (fruit fly) experiment from the recent NASA Research Announcements (**NNH12ZTT001N **) to fly on SpX-7 in 2015. (Title:** The Effects of Microgravity on Cardiac Function, Structure and Gene Expression using the Drosophila Model)

➢ **There is therefore interest from both the general public and from the science community to conduct Drosophila research in space, making it an important endeavor to develop Fruit Fly Lab (FFL) hardware for future space flight missions.**